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Understanding the structure of human dental tissues and their carious decay using advanced correlative microscopy

Human dental tissues are hydrated biological mineral composites of hydroxyapatite crystallites within an organic matrix. Dentine and enamel have a hierarchical structure that delivers their versatile mechanical properties. These composites demonstrate superb thermo-mechanical stability, but suffer biological and chemical degradation (decay) due to one of the most widespread diseases, human dental caries, that arises as a consequence of modern sugar-rich diet and proceeds through the proliferation of acid-producing bacteria residing in the biofilm known as plaque. A strong and durable bond between dentine and enamel is formed by the dentine enamel junction (DEJ), an important biological interface that resists failure under long-term harsh thermal and mechanical conditions in the mouth. Understanding the underlying reasons for this remarkable combination of strength and toughness remains an important challenge, both in the context of dentistry and from the point of view of pursuing biomimetic advanced materials engineering. Residual strain develops in the vicinity of the DEJ during odontogenesis (tooth formation). The experimental and interpretational challenges that could not be overcome until recently presented an obstacle to the evaluation of residual stress in the vicinity of the DEJ at the appropriate spatial resolution. We used the recently developed FIB-DIC micro-ring-core method to determine the residual elastic strain at micron resolution. The residual strain profiling across the transition from dentine to enamel are correlated with the study of internal architecture using X-ray scattering (SAXS/WAXS). We illustrate how this provides improved insight into the origins of the remarkable performance of the DEJ. Further insights into dental erosion due to acid exposure will be provided.

Recent Publications

1. T Sui, A J G Lunt, N Baimpas, M A Sandholzer, J Hu, I P Dolbnya, G Landini, A M Korsunsky (2014) Hierarchical modeling of in situ elastic deformation of human enamel based on photoelastic and diffraction analysis of stresses and strains. *Acta biomaterialia*; 10(1): 343-354.

2. T Sui, M A Sandholzer, N Baimpas, I P Dolbnya, A Walmsley, P J Lumley, G Landini, A M Korsunsky (2013) Multiscale modelling and diffraction-based characterization of elastic behaviour of human dentine. *Acta biomaterialia*; 9(8): 7937-7947.

Biography

Alexander M Korsunsky leads MBLEM lab at the University of Oxford and the Centre for In situ processing science (CIPS) at Research Complex at Harwell. He consults Rolls-Royce plc on matters of residual stress and structural integrity and is Editor-in-Chief of Materials & Design, a major Elsevier journal.

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